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(54) **FLEXIBLE HEAT DISSIPATION DEVICE**

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CPC ***F28D 15/0241*** (2013.01); ***F28D 15/043*** (2013.01); *F28D 15/046* (2013.01); *F28D 2015/0216* (2013.01)

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See application file for complete search history.

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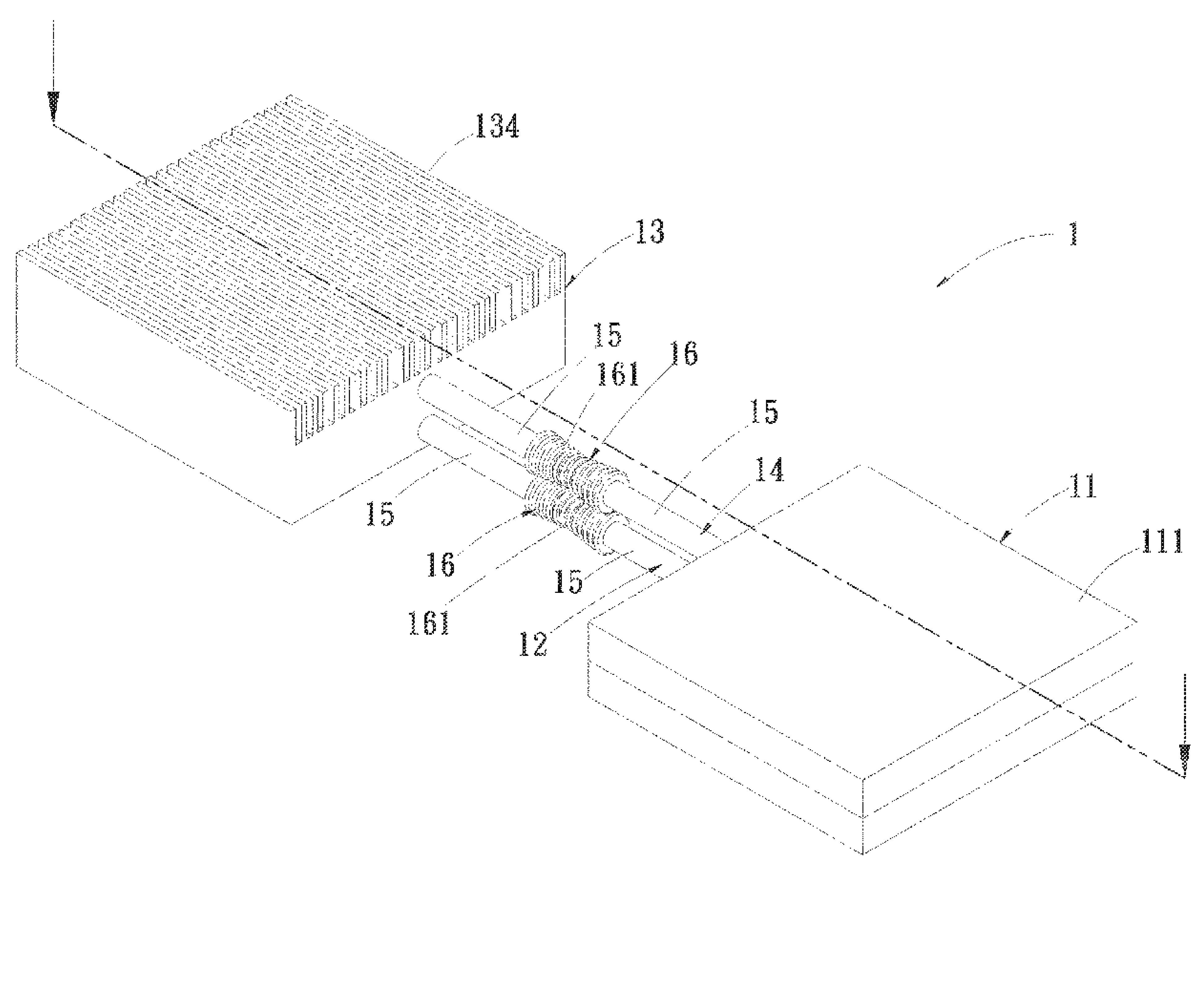
(57) **ABSTRACT**

A flexible heat dissipation device includes an evaporator, a vapor tube, a liquid tube and a condenser. The evaporator has at least one vapor chamber. A capillary structure and a working fluid are received in the vapor chamber. Two ends of the vapor tube is respectively in communication with one end of the evaporator and the condenser. Two ends of the liquid tube are respectively in communication with the evaporator and the condenser, whereby the evaporator, the vapor tube, the condenser and the liquid tube form a loop for the working fluid to flow through. At least one bellows section is disposed on one or both of the vapor tube and the liquid tube. The bellows section has multiple waved stripes. More than one of the heights, widths and pitches of the multiple waved stripes are equal to or unequal to each other.

5 Claims, 6 Drawing Sheets



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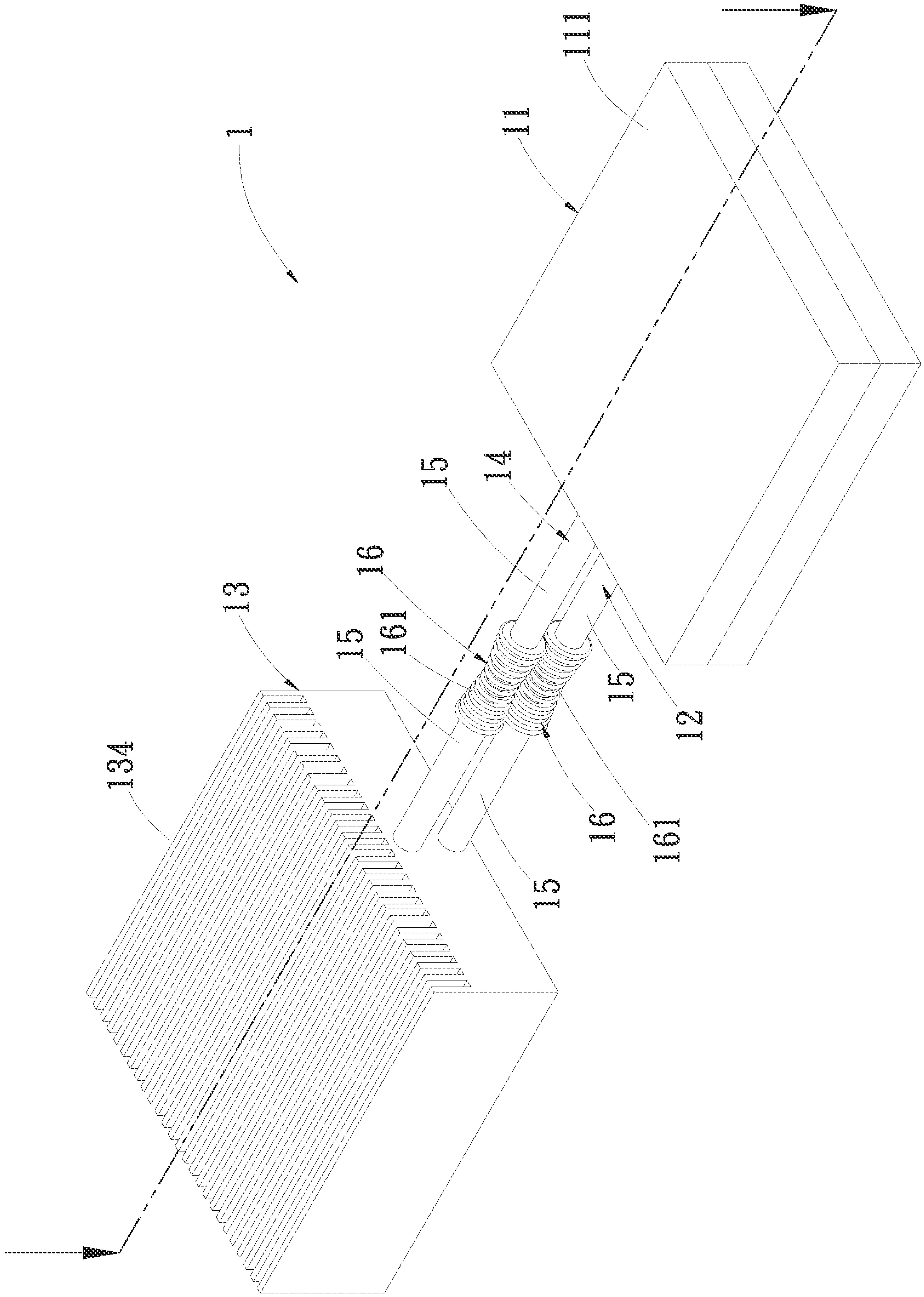

Fig. 1A

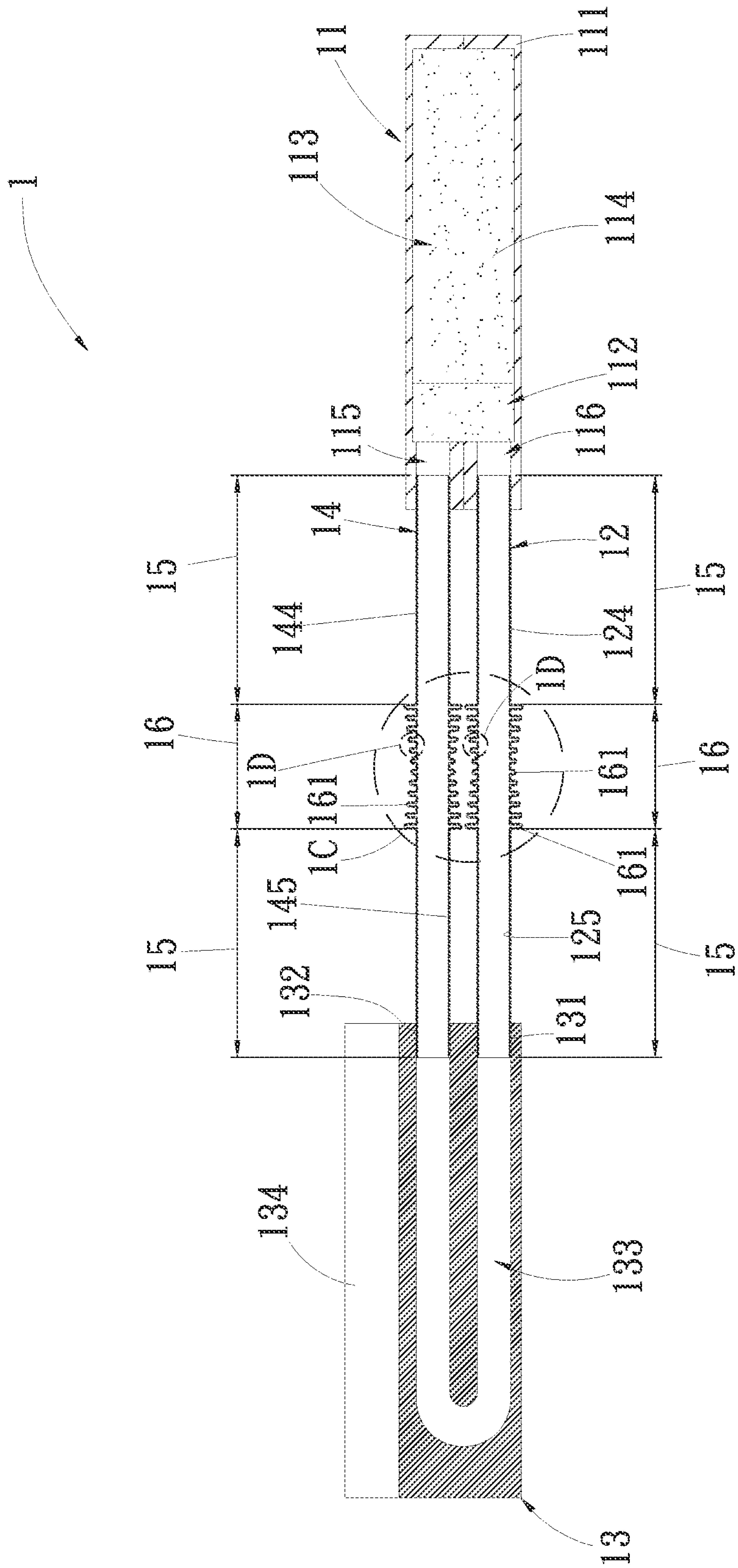
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Fig. 1B

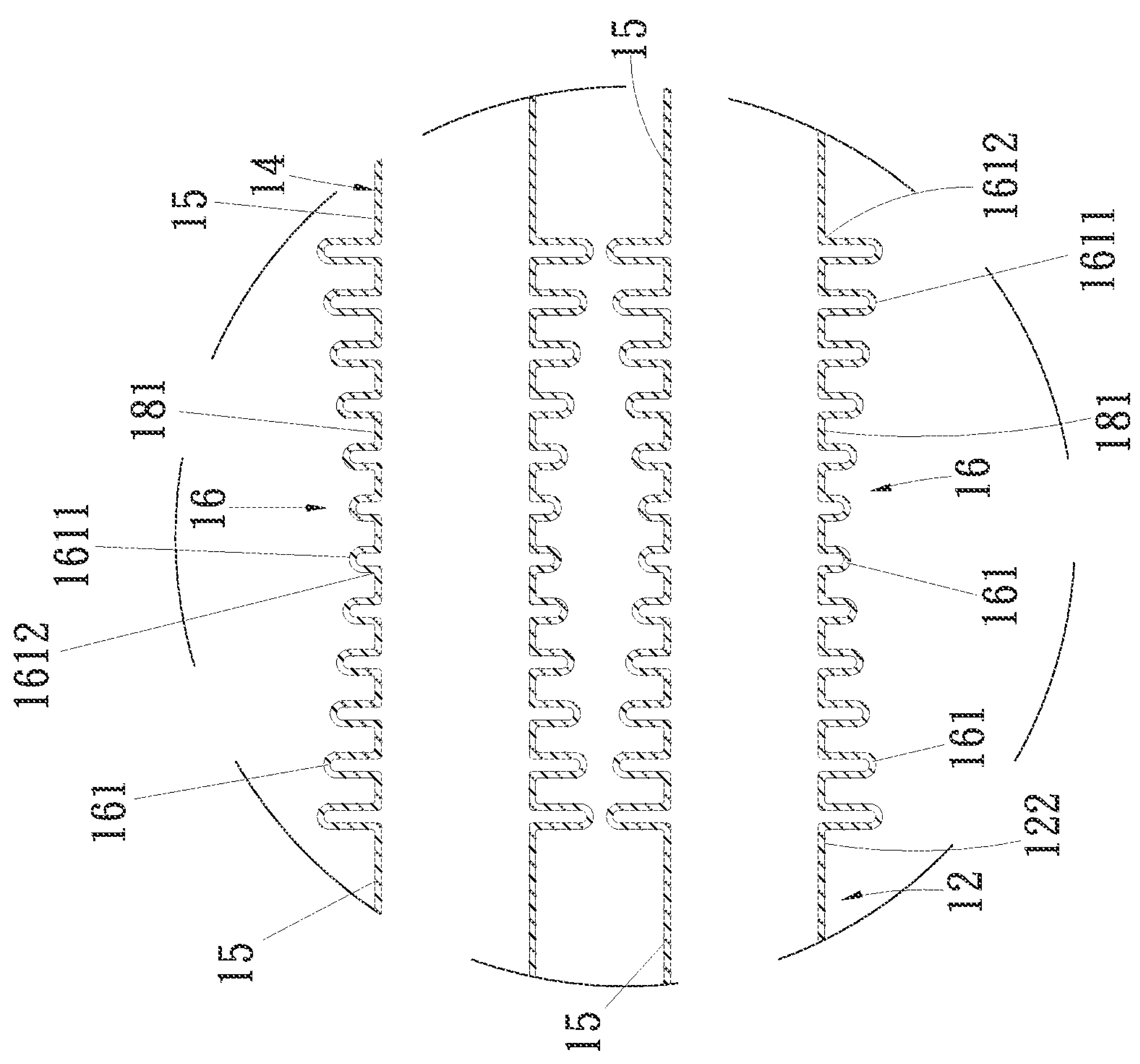
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Fig. 1C

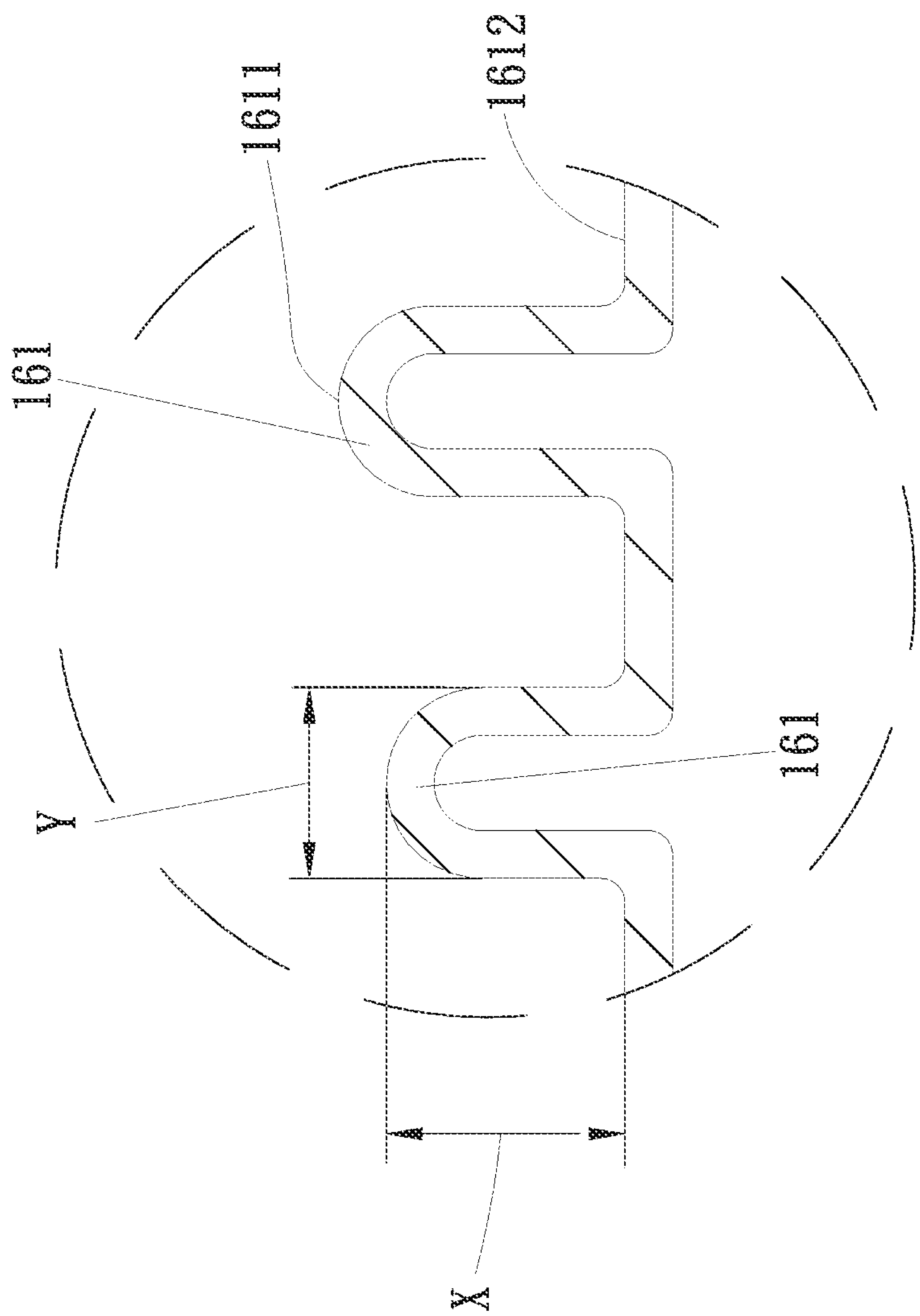

Fig. 1D

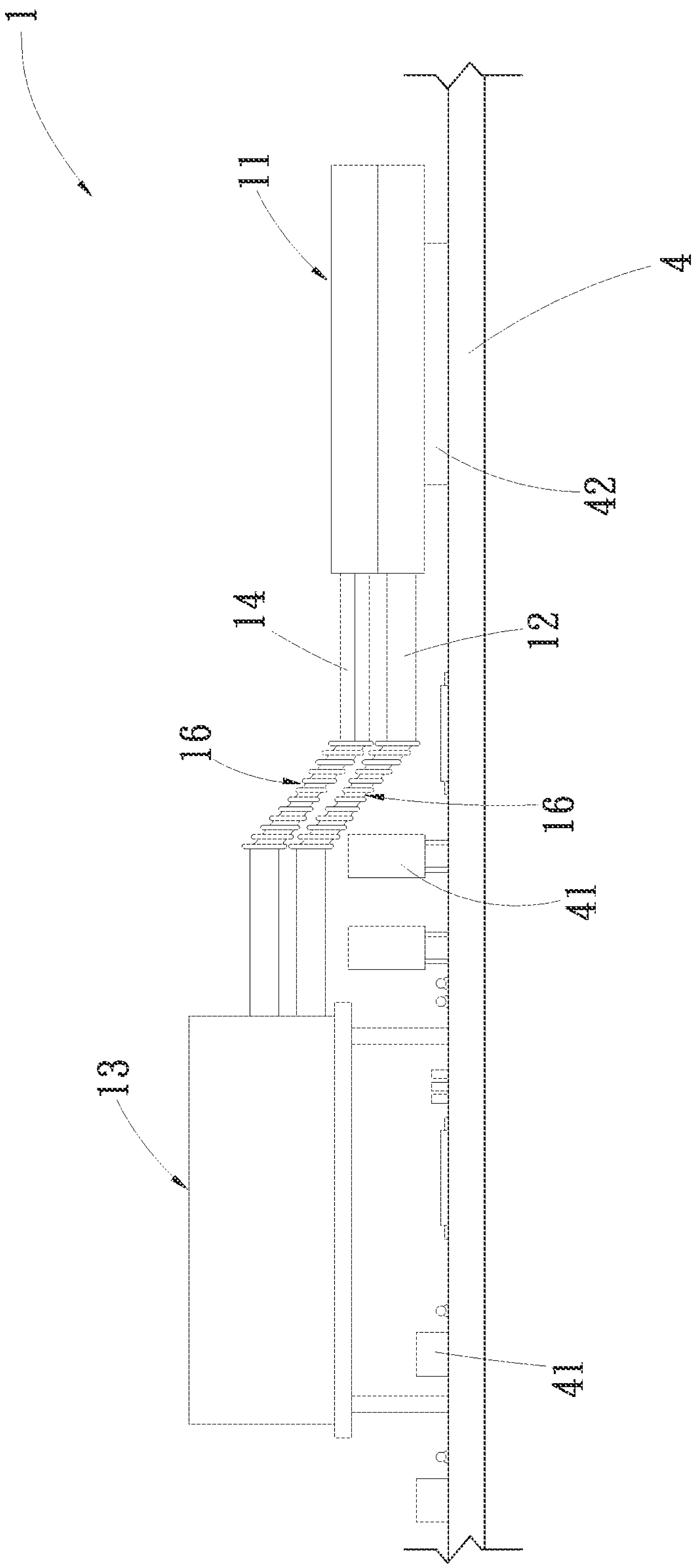

Fig. 2

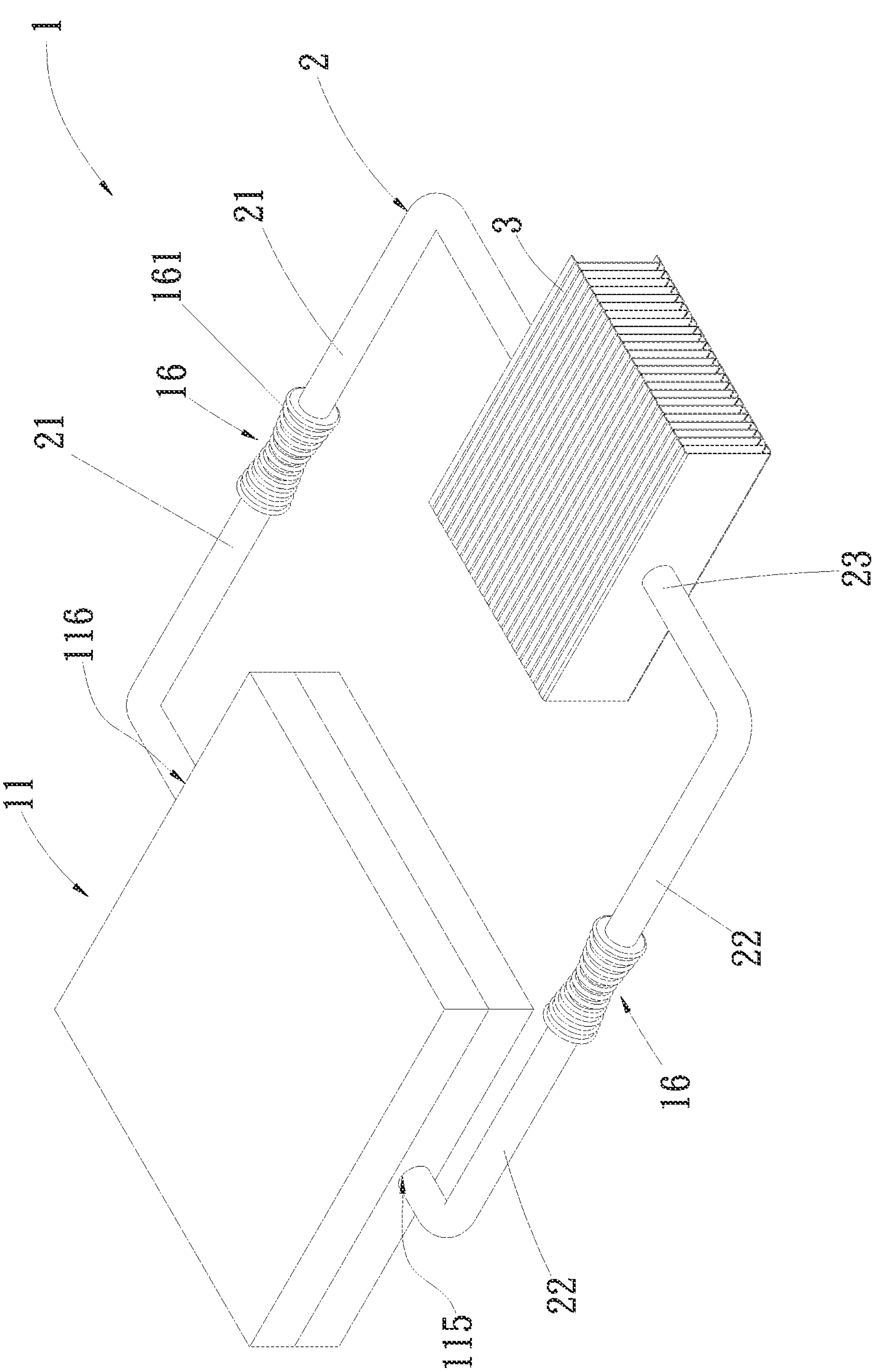

Fig. 3

FLEXIBLE HEAT DISSIPATION DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a flexible heat dissipation device, and more particularly to a flexible heat dissipation device, which can be bent to absorb the bridging force of the tubes.

2. Description of the Related Art

Along with the continuous increase of the power of the electronic components such as central processing unit, heat dissipation problem has been more and more valued. The loop heat pipe has high heat transfer performance so that the loop heat pipe is widely applied in heat dissipation field.

In general, a conventional loop heat pipe includes an evaporation section, a condensation section and a vapor tube and a liquid tube disposed between the evaporation section and the condensation section. The vapor tube and the liquid tube connect the evaporation section and the condensation section to form a loop, in which pure water is filled. The evaporation section is connected with a heat generation component (such as a central processing unit or a graphics processing unit). When the evaporation section of the loop heat pipe absorbs the heat of the heat generation component, the pure water in the evaporation section is heated and evaporated into vapor. The vapor passes through the vapor tube and flows to the condensation section of the loop heat pipe. The heat is radiated from the condensation section and the vapor is condensed into liquid. After condensed, the liquid working medium passes through the liquid tube and flows back to the evaporation section to complete a circulation. Accordingly, the pure water is repeatedly evaporated and condensed to continuously absorb heat and dissipate the heat so as to achieve the heat exchange effect. However, multiple electronic components (such as capacitors, transistors, resistors and inductors) are arranged around the heat generation component on the motherboard in the electronic device (such as a server or a communication chassis). The heat generation component and the other electronic components around the heat generation component have different heights so that the vapor tube and the liquid tube of the loop heat pipe must be previously designed to bypass and avoid the multiple electronic components on the motherboard. In this case, there is room for arranging the vapor tube and the liquid tube. As a result, the loop heat pipe cannot be applied to various specifications or model Nos. of motherboards. In addition, it is necessary for the vapor tube and the liquid tube to bypass and avoid the multiple electronic components so that the cost is increased. Moreover, the evaporator is attached to the outer surface of the heat generation component, while the condensation section is securely assembled on the outer surface of a fixed platform. The evaporator and the condensation section are not positioned on the same level. Furthermore, the evaporation section and the condensation section are connected by means of inflexible (unbendable) vapor tube and liquid tube, which are made of inflexible metal material (via straight copper tube welding). Also, these tubes have considerable length. Therefore, it is hard to control the levels of the evaporation section and the condensation section in assembling process. In case the evaporation section and the condensation section are forcedly assembled in two different positions, (that is, the heat generation component and the fixed platform) with different levels, the bridging force of these tubes will pull the evaporation section and the condensation section. In this case, the evaporation section can hardly snugly attach to and contact the surface of the heat generation component. Also, the condensation section can hardly snugly attach to and contact the surface of the fixed platform.

SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to provide a flexible heat dissipation device, which can be bent to absorb the bridging force of the tubes.

It is a further object of the present invention to provide the above flexible heat dissipation device, in which the evaporator can snugly attach to and contact the surface of the heat generation component and the condenser can snugly attach to and contact the surface of a component in an electronic device.

It is still a further object of the present invention to provide the above flexible heat dissipation device, in which at least one bellows section is disposed on one or both of the vapor tube and the liquid tube. The bellows section can be freely bent and deformed by any angle or in any direction, whereby the heights of the vapor tube and the liquid tube can be adjusted so that the vapor tube and the liquid tube can be assembled and aligned with the corresponding evaporator, condenser and heat generation component.

To achieve the above and other objects, the flexible heat dissipation device of the present invention includes an evaporator, a vapor tube, a liquid tube and a condenser. The evaporator has at least one vapor chamber, a liquid inlet and a vapor outlet. A capillary structure and a working fluid are received in the vapor chamber. The liquid inlet and the vapor outlet are in communication with the vapor chamber. One end of the vapor tube is in communication with the vapor outlet. The other end of the vapor tube is in communication with the condenser. Two ends of the liquid tube are respectively in communication with the evaporator and the condenser, whereby the evaporator, the vapor tube, the condenser and the liquid tube form a loop for the working fluid to flow through. At least one bellows section is disposed on one or both of the vapor tube and the liquid tube. The bellows section has multiple waved stripes. More than one of the heights, widths and pitches of the multiple waved stripes are equal to or unequal to each other.

Still to achieve the above and other objects, the flexible heat dissipation device of the present invention includes an evaporator, at least one bellows section and a vapor/liquid loop tube. The evaporator has a vapor chamber, a liquid inlet and a vapor outlet. A capillary structure and a working fluid are received in the vapor chamber. The liquid inlet and the vapor outlet are in communication with the vapor chamber. The vapor/liquid loop tube has a vapor section and a liquid section. One end of the vapor section and one end of the liquid section are respectively in communication with the vapor outlet and the liquid inlet. The other end of the vapor section outward integrally extends to connect with the other end of the liquid section and a condensation section is formed therebetween. A condensation component is disposed on outer side of the condensation section. At least one bellows section is disposed on one or both of the vapor section and the liquid section. The bellows section has multiple waved stripes. More than one of the heights, widths and pitches of the multiple waved stripes are equal to or unequal to each other.

A tube body capillary structure is disposed in the liquid tube. The tube body capillary structure is disposed on the inner surface of the liquid tube.

According to the design of the above embodiments of the present invention, the flexible heat dissipation device of the present invention can be flexed (bent) to absorb the bridging force of the tubes. Moreover, the flexible heat dissipation device of the present invention is adapted and applicable to different electronic components on the circuit board in various electronic devices (such as a server, a computer or a communication chassis) with height differences. The evaporator can effectively snugly tightly attach to the heat generation component.

BRIEF DESCRIPTION OF THE DRAWINGS

The structure and the technical means adopted by the present invention to achieve the above and other objects can be best understood by referring to the following detailed description of the preferred embodiments and the accompanying drawings, wherein:

FIG. **1**A is a perspective assembled view of a first embodiment of the flexible heat dissipation device of the present invention;

FIG. **1**B is a sectional view of the first embodiment of the flexible heat dissipation device of the present invention;

FIG. **1**C is an enlarged view of circled area **1**C of FIG. **1**B, showing the bellows sections of the vapor tube and the liquid tube of the flexible heat dissipation device of the present invention;

FIG. **1**D is an enlarged view of circled area **1**D of FIG. **1**B, showing the waved stripes of the bellows section;

FIG. **2** is a side view showing that the first embodiment of the flexible heat dissipation device of the present invention is applied to an electronic device; and

FIG. **3** is a perspective assembled view of a second embodiment of the flexible heat dissipation device of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Please refer to FIGS. **1**A to **3**. The flexible heat dissipation device **1** of the present invention can be a loop heat pipe (LHP) or a two-phase loop thermosyphon (LTS). The flexible heat dissipation device **1** includes an evaporator **11**, a vapor tube **12**, a condenser **13**, at least one bellows section **16** and a liquid tube **14**. The evaporator **11** is tightly attached to a heat generation component **42** (such as a central processing unit or a graphics processing unit) on a circuit board **4** (such as a motherboard) in an electronic device (such as a server, a computer or a communication chassis). The circuit board **4** further includes multiple electronic components **41** with different heights, (such as capacitors, resistors, inductors or transistors). The electronic components **41** are arranged around the heat generation component **42**. The evaporator **11** has a case **111**, at least one vapor chamber **113**, a liquid inlet **115** and a vapor outlet **116**. The case **111** is made of metal material (such as stainless steel, titanium, aluminum, copper or other metal). The inner wall of the case **111** defines the vapor chamber **113**. At least one capillary structure **114** and a working fluid are received in the vapor chamber **113**. The capillary structure **114** is a porous structure selected from a group consisting of sintered powder, micro-channel, woven mesh, fiber, braid body and any combination thereof as a complex capillary structure. In this embodiment, the capillary structure **114** is, but not limited to, a woven mesh for illustration. The working fluid is such as pure water, methyl alcohol, distilled water or a mixture thereof. The working fluid is converted between vapor phase and liquid phase to achieve heat transfer.

In this embodiment, the liquid inlet **115** and vapor outlet **116** are, but not limited to, respectively formed on the same side of the case **111** and the liquid inlet **115** is positioned above the vapor outlet **116**. In practice, the liquid inlet **115** and the vapor outlet **116** can be alternatively respectively disposed on the opposite sides of the case **111**. The liquid inlet **115** and vapor outlet **116** are in communication with the vapor chamber **113**. A vapor passage **112** is defined between the vapor chamber **113** in the case **111** and the corresponding vapor outlet **116**. The vapor passage **112** is in communication with the vapor outlet **116** and one end of the vapor tube **12**. Accordingly, after evaporated, the vapor working fluid passes through the vapor passage **112** and the vapor outlet **116** to enter the vapor tube **12**.

The vapor tube **12** and the liquid tube **14** are made of metal material (such as stainless steel, titanium, aluminum, copper or other metal). One end of the vapor tube **12** is connected with the vapor outlet **116** of the case **111** so that the end of the vapor tube **12** is in communication with the vapor outlet **116** and the vapor chamber **113**. The other end of the vapor tube **12** is in communication with the condenser **13**. The condenser **13** is connected with a component in the electronic device, (such as a fan support or heat dissipation fixed platform). In this embodiment, the condenser **13**, (which can be a radiator or water-cooling radiator), has a vapor inlet **131**, a liquid outlet **132**, a vapor/liquid mixture passage **133** and multiple radiating fins **134**. The vapor/liquid mixture passage **133** extends upward from the vapor inlet **131** to the liquid outlet **132** to connect and communicate with the liquid outlet **132**. The multiple radiating fins **134** are arranged on the outer surface of the top section of the condenser **13** at intervals. The other end of the vapor tube **12** connects and communicates with the vapor inlet **131**. One end and the other end of the liquid tube **14** respectively connect and communicate with the liquid outlet **132** and the liquid inlet **115**. Two ends of the liquid tube **14** respectively communicate with the evaporator **11** and the condenser **13**, whereby the evaporator **11**, the vapor tube **12**, the condenser **13** and the liquid tube **14** form a loop for the working fluid to flow through. When the evaporator **11** absorbs the heat of the heat generation component **42**, the working fluid in the evaporator **11** is heated and evaporated to produce vapor working fluid. By means of pressure difference, the vapor working fluid in the vapor passage **112** is driven to pass through the vapor outlet **116** and the vapor tube **12** and flow through the vapor inlet **131** into the vapor/liquid mixture passage **133** of the condenser **13**. The condenser **13** and the multiple radiating fins **134** absorb the heat of the vapor working fluid, whereby the vapor working fluid is condensed and converted into liquid working fluid. The liquid working fluid passes through the liquid outlet **132** and the polished inner surface **145** of the liquid tube **14** to flow through the liquid inlet **115** back into the vapor chamber **113** of the evaporator **11** for next circulation. The vapor tube **12** and the liquid tube **14** are respectively connected with the evaporator **11** and the condenser **13** by means of welding, insertion or adhesion.

At least one bellows section **16** is disposed on one or both of the vapor tube **12** and the liquid tube **14**. In this embodiment, the bellows sections **16** are disposed on both of the vapor tube **12** and the liquid tube **14**. Two ends of the bellows section **16** are respectively connected with a straight section **15**. The bellows section **16** has multiple waved stripes **161** arranged at intervals or continuously. The multiple waved stripes **161** are multiple recessed/raised structures or wave peaks and wave troughs, which are alternately arranged. The bellows section **16** has excellent extensible/contractible elasticity and can be bent and folded onto itself (into a U-shaped configuration) to achieve shock absorption effect. In a preferred embodiment, the bellows section **16** is disposed on the vapor tube **12** or the liquid tube **14**.

In this embodiment, at least one of the vapor tube **12** and the liquid tube **14** has a polished inner surface or a tube body capillary structure is disposed on the inner surface of the tube body of the vapor tube **12** or the liquid tube **14**.

In addition, more than one of the heights X, widths Y and pitches **181** of the multiple waved stripes **161** are equal to or unequal to each other. The pitches **181** of the multiple waved stripes **161** can be equal to or unequal to each other. Each waved stripe **161** has a waved stripe top end **1611** and a waved stripe bottom end **1612**. The waved stripe bottom end **1612** is positioned in adjacency to an outer surface **124**, **144** of each of the vapor tube **12** and the liquid tube **14**. (That is, the waved stripe bottom end **1612** is positioned on the same level as the outer surface **124**, **144** or positioned on a level higher/lower than the outer surface **124**, **144**). The waved stripe top end **1611** is raised from the outer surface **124**, **144** of each of the vapor tube **12** and the liquid tube **14**. The height X of the waved stripe **161** is defined between the waved stripe top end **1611** and the waved stripe bottom end **1612**.

Please refer to the respective drawings. The heights X of the multiple waved stripes **161** are equal to or unequal to each other. For example, the heights X of the multiple waved stripes **161** are gradually decreased from two sides of the bellows section **161** to the middle thereof. That is, the heights X of the waved stripes **161** at the middle of the bellows section **16** are lower and the heights X of the waved stripes **161** on two sides of the bellows section **16** are gradually increased. The heights X of the waved stripes **161** at the middle of the bellows section **16** are lower than the heights X of the waved stripes **161** on two sides of the bellows section **16** so that when the bellows section **16** is bent, the waved stripes **161** at the middle of the bellows section **16** will not interfere with the waved stripes **161** on two sides of the bellows section **16**. Therefore, the bellows section **16** can be freely flexed (bent) by any angle or in any direction or folded onto itself. This improves the problem that the bending angle of the bellows section is limited. Moreover, the flexible heat dissipation device of the present invention is adapted and applicable to various circuit boards **4** and the electronic components **41** on the circuit boards **4** with height differences.

Please now refer to FIG. **3** as well as FIGS. **1**C and **1**D. In a modified embodiment, the liquid tube **14** and the vapor tube **12** of the above embodiment are modified into one single loop. Two ends of the loop communicate with the liquid inlet **115** and the vapor outlet **116** of the evaporator **11**. For easy illustration, the loop is so-termed vapor/liquid loop tube **2** hereinafter. The vapor/liquid loop tube **2** has a vapor section **21** and a liquid section **22**. One end of the vapor section **21** and one end of the liquid section **22** are respectively in communication with the vapor outlet **116** and the liquid inlet **115** and the vapor chamber **113**. The other end of the vapor section **21** outward integrally extends to connect with the other end of the liquid section **22** and a condensation section **23** is formed therebetween. A condensation component **3** (such as multiple radiating fins) is disposed on outer side of the condensation section **23**. At least one bellows section **16** is disposed on one or both of the vapor section **21** and the liquid section **22**. In this embodiment, there are two bellows sections **16** respectively disposed on both of the vapor section **21** and the liquid section **22**. Each bellows section **16** has multiple waved stripes **161** arranged at intervals (or continuously). The features of the bellows section **16**, (that is, the heights X, widths Y and pitches **181** of the waved stripes **161** are equal to or unequal to each other), are identical to those of the aforesaid bellows section **16** and thus will not be redundantly described hereinafter.

It should be noted that the multiple waved stripes **161** of the bellows section **16** are annular waved stripes surrounding the tube bodies of the vapor tube **12** and the liquid tube **14** as closed loops. In a modified embodiment, the multiple waved stripes **161** are spiral waved stripes arranged around the tube bodies of the vapor tube **12** and the liquid tube **14** in a spiral form.

Please refer to the respective drawings. When the flexible heat dissipation device **1** is assembled on the electronic device, the evaporator **11** is attached to the heat generation component **42**. Thereafter, by means of the bellows section **16** of one of the vapor tube **12** and the liquid tube **14**, the flexible heat dissipation device **1** can be freely bent by any angle or in any direction, (such as upward, downward, leftward or rightward bent) to deform and adjust the position. The multiple waved stripes **161** provide excellent extensible/contractible elasticity, whereby the vapor tube **12** and the liquid tube **14** can be extended to elongate the length so as to bypass the higher electronic component **41** around the heat generation component **42**. Also, the bellows section **16** can absorb the pull applied by the vapor tube **12** and the liquid tube **14** to the evaporator **11** and the condenser **13** due to the bridging force of these tubes.

The present invention has been described with the above embodiments thereof and it is understood that many changes and modifications in such as the form or layout pattern or practicing step of the above embodiments can be carried out without departing from the scope and the spirit of the invention that is intended to be limited only by the appended claims.

What is claimed is:

1. A flexible heat dissipation device comprising:

a condenser;

an evaporator having at least one vapor chamber, a liquid inlet and a vapor outlet, a capillary structure and a working fluid being received in the vapor chamber, the liquid inlet and the vapor outlet being in communication with the vapor chamber;

a vapor tube, one end of the vapor tube being in communication with the vapor outlet, the other end of the vapor tube being in communication with the condenser;

a liquid tube, two ends of the liquid tube being respectively in communication with the evaporator and the condenser, whereby the evaporator, the vapor tube, the condenser and the liquid tube form a loop for the working fluid to flow through; and

at least one bellows section disposed on one or both of the vapor tube and the liquid tube, the bellows section having multiple waved stripes, one or more of heights, widths and pitches of at least one of the multiple waved stripes being unequal to a height, a width and a pitch of an adjacent one of the multiple waved stripes;

wherein the heights of the multiple waved stripes are gradually decreased from two sides of the bellows section to a middle of the bellows, so that when the bellows section is bent, the waved stripes at the middle of the bellows section will not interfere with the waved stripes on the two sides of the bellows section.

2. The flexible heat dissipation device as claimed in claim **1**, wherein each waved stripe has a top end and a bottom end, the bottom end being positioned on an outer surface of each of the vapor tube and the liquid tube, the top end being raised from the outer surface of each of the vapor tube and the liquid tube.

3. The flexible heat dissipation device as claimed in claim **2**, wherein the height of each waved stripe is defined between the top end and the bottom end.

4. The flexible heat dissipation device as claimed in claim **1**, wherein the multiple waved stripes are annular waved stripes or spiral waved stripes.

5. The flexible heat dissipation device as claimed in claim **1**, wherein the capillary structure is selected from a group consisting of sintered powder, micro-channel, woven mesh, fiber and any combination thereof as a complex capillary structure.

* * * * *